Hands-On Hydrology

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Abstract:
A professional school and university collaboration enables elementary students and their teachers to explore hydrology concepts and realize the beneficial functions of wetlands. Hands-on experiences involve young students in determining water quality at field sites after laying the groundwork with activities related to the hydrologic cycle, cleaning up polluted water, and the nature of wetlands themselves.
Key words: groundwater, hydrology, surface water, water cycle, wetlands

Article:

Elementary school kids love mud, water, and icky water creatures. Capitalizing on this interest is a pretty easy thing for a teacher to do, but it takes planning and organization to do so safely and to provide maximum learning opportunities. Students of all ages need to learn about the nature of hydrology, the functions of local wetlands, and global water quality issues. Learning from direct experience is a way to tie these appealing and important entities together. As a classroom teacher, I was able to accomplish this several years ago and have been able to use my experience to enrich my teaching ever since.

Background Information

Hydrology is simply the study of water. Hydrology may be defined as the study of the earth's water in the atmosphere, on the planet's surface, and underground, and it includes water's properties, distribution, circulation, and characteristics. Water flows above the earth as surface water and below it as ground water. Precipitation that runs over land in creeks and rivers is called surface water. Most surface water is a result of precipitation. Precipitation that percolates through soils becomes known as ground water. These waters are connected and interrelated, thus making the water cycle. However, with students, surface water is the most easily accessible for observations and sampling.

Although the nature of hydrology itself is the main concept that you want students to understand after these studies, you also want them to realize the impact of humans on natural water cycles, consider ways to halt the pollution that disrupts food webs, and recognize the valuable services provided by wetlands in actually undoing some of our damage.

The Year-long Experience

Putting the plan together for this professional/school/university partnership in hydrology was an effort of university science educators, public school teachers, and professional hydrologists with the United States Geological Survey (USGS) National Water Quality Assessment Program. The mission of this organization is to assess the quality of our nation's water resources. Experienced teachers and preservice education majors teamed up for a year-long training to understand the relevance of hydrology to their roles as elementary teachers and to find ways to impart this information to young students.

Under the terms of a grant, we were provided with classroom posters about types of wetlands, wastewater treatment, water use, groundwater, and water quality. USGS experts took us to two representative public wetland areas that we would later use with our own students. (If we had wanted to visit privately owned property, written permission from the landowner would have been required.) We became familiar with waders, field guides, notebooks, seines (large fishing nets), dip nets, and collecting containers, and we learned to conduct some simple tests for water quality. The grants also provided HACH kits, which we used to analyze samples from both sites for chemicals such as nitrate, sulfate, and chloride, as well as dissolved oxygen, and we also were able to observe the practicing professional hydrologists using conductance meters. Because these and other tests can be used to evaluate the overall health of a body of water, we monitored physical characteristics of each wetland site, including collecting data on turbidity and pH of the water. (See Figure 1, Simple Water Tests, for brief explanations of tests that can be performed for each characteristic.) To determine the overall health of the site, we used nets to collect samples of macroinvertebrate organisms and compared the samples by taxa on the basis of pollution sensitivity.

Follow-up trips for elementary school students from public schools were scheduled to let the younger children have many of the same experiences we had. At each participating school, one teacher, known as a Hydrologist-in-Residence, was provided with a substitute teacher, freeing her to return to the wetland sites with each of the other classes from her school throughout the year.

As Hydrologist-in-Residence, I took care of the measuring, testing, and collecting equipment; scheduled the dates and transportation for each class visit; and conducted one or more explanatory sessions at my school mini-pond for each group before doing the wetlands field trip. I demonstrated the testing procedures through an actual comparison of school tap water to the water in the mini-pond at my school. I then explained the features, functions, and purposes of the field trip itself. Over 150 students participated that first year from my school alone, and more than one hundred students repeat the class work and field experience annually since that first effort seven years ago. Cooperation between the schools led us to test, sample, and submit data to the USGS monthly for further evaluation. Data from every class visit were added to a school hydrology database as well. As changes were noted, the students generated hypotheses about causes and potential consequences of the fluctuations of the various tests conducted.

Preparing for the Field Trip

In preparation for the elementary school trips, the teachers and their university interns planned appropriate science lessons for the various grade levels involved. Classes considered hydrology, including the biology of the wetland sites. Every class became acquainted with the local macroinvertebrates, aquatic birds, and amphibians of their area. (Note that you may or may not find all these kinds of animals in your area.) A colony of beavers was active at one of the sites, so beavers and their adaptations were included as well. Teachers chose high quality children's trade literature, relevant poetry and songs, graphic organizers, and other writing opportunities to integrate literacy curriculum components. Literature suggestions and teacher resources can be found in the bibliography at the end of this article.

Selecting categories of hydrology according to developmental levels and curriculum responsibilities, each classroom teacher used hands-on activities to further students' understanding of hydrology. Typically, a class inside the school building will explore water cycle concepts (see Figure 2, The Water Cycle); issues of water contamination and pollution (see Figure 3, Muddying the Water; and Figure 4, Cleaning the Waters); and food web relationships (see Figure 5, Cattail Web of Life) before setting out on a wetlands site visit. Sometimes, though, the activity is even more applicable at the site itself. Figure 6, Metaphors in the Wetland, gains more impetus when the comparisons are made to visible living organisms and the water itself. Inside or out, it is ideal to have as many adults as possible to coach, observe, and set things up for success. Collaboration between professional hydrologists, working educators, and preservice university education students can benefit all facets of the educational spectrum in such an arrangement.

Teachers conducted precipitation and condensation demonstrations (see Figure 7, Precipitation and Condensation). Some teachers explored the adhesive and cohesive properties of water as well as related the percolation of water to the percolation of coffee (see Figure 8, Percolation). Teachers sometimes included experiments investigating transpiration and evaporation (see Figure 9, Transpiration and Evaporation) and demonstrations of cloud formation (see Figure 10, Cloud Formation).

The classes addressed safety concerns such as hot water temperatures during these indoor experiments and demonstrations. Students discussed and recorded their observations and discoveries about the behavior of water. Sometimes this took the form of a concept map around the central focus of hydrology. The younger students conducted research and experiments based upon their own KWL charts, including K (knowledge), W (what they wonder), L (learning that answers their own questions).

The Save our Streams Web site (www.saveourstreams.org) has the following materials that will be useful in wetland trips: (1) data collection sheets including stream study sample record and assessment forms at http://www.people.virginia.edu/~sos-iwla/Stream-Study/Methods/Form. HTML (2) an aquatic macroinvertebrates identification key at http://www.people.virginia.edu/~sos-iwla/Stream-Study/Key/MacroKey-Intro.HTML (3) a list of sampling materials and equipment needed at http://www.people.virginia.edu/~sos-iwla/Stream-Study/Methods/Materials.HTML and (4) wetlands fact sheets, videos, posters, and a science project guide for students at http://www.iwla.org/sos/, which is the Izaak Walton League's National Save our Streams Program Web site.

Wetland Experiences

During the initial year of the hydrology focus, we had specific requirements for the USGS field form. These data requirements included information such as bank vegetation, stream channel width, bankful channel depth, various qualitative descriptions of habitat, and a list of animals and plants observed at each site. Even afterward, however, we used the same field report format that comprised both visual observations of conditions and particular tests or measurements.

Students conducted most of the chemical tests except the pouring of chemical reagents. Because the small powder packets posed an inhalation hazard, an adult performed this task. Students conducted the mixing, timing, and comparison of the tested sample to the appropriate color wheel to determine the level of the chemical constituent present. For younger students, we restricted the chemical tests to two likely culprits from runoff: nitrogen and phosphorous. High concentrations of nitrates and phosphates are evidence of excessive or untimely fertilizing of local lawns and gardens. Phosphorous is also found in household detergents and cleaning products. The children were familiar with these common products and could connect the idea of careless use or overuse to their own experiences at home.

Students conducted measurements of stream flow, stream depth, and temperature, as well as turbidity and pH. We took safety precautions to assure steady footing for these tasks. Students entered their observations and findings on the field form and determined a water quality index value for the macroinvertebrates that were netted. The water quality index is a value that is computed based on the numbers and kinds of invertebrates found. Certain invertebrates are indicative of water quality because they survive only in specific conditions. Students identify and count the number of invertebrates found and record that data. They then use a simple formula to compute water quality, which can range from excellent to poor. A simple water quality rating form can be found online at http://www.people.virginia.edu/~sos-iwla/Stream-Study/Methods/Form. HTML. We adults were truly as entranced with the crayfish, backswimmers, water boatmen, leeches, snails, and other specimens as the students were.

Conclusion

Connecting the physical nature of water and its cycles to life in the wetlands in this fashion combines and integrates hydrology with biology beautifully. Students share both relevant classroom experiences and field adventures, actively bonding their learning. As an individual, speaking not only from a teaching perspective, I will always be grateful for both my first and my continuing opportunities to swamp around outdoors, borrowed waders and all, with interested and excited children. We all love seeing ducks, geese, herons, redwinged blackbirds, turtles, frog eggs, fish, tadpoles, rabbits, and countless nifty, crawling creatures. We had fun, indoors and out, every time, and all are richer for the experience.

If you want to set up an ongoing monitoring of a local wetland site, funding might be obtained from the state or county water or land conservation bureau, or through a city administration. Advice and assistance may be obtained through your local Stream Watch organization or county extension agency. Faculty members at a nearby university or a high school may also be able to help. For a list of starter equipment to get your students out mucking around in the out-of-doors see Figure 11, Minimal Start-up Supplies and Equipment.

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ADDED MATERIAL

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Water Tests

Phosphate and Nitrate Levels: (S)* conduct tests on small samples of water from the wetland sites to determine levels of these nutrients using components of a commercial water quality test kit. (T)* pours chemical reagents due to inhalation risk. Then students time and observe color changes.

pH for Acidity or Alkalinity: (S) wear goggles and protective gloves to test water with pH paper or an acid rain test kit. Students record the pH values on the field report form.

Dissolved Oxygen: (S) wear goggles to collect and test water samples from the wetland sites for dissolved oxygen using a commercial water quality test kit. For repeated tests, conduct them at the same place and same time of day.

Turbidity: (S) make a measurement device to submerge in a stream or pond from a white plastic picnic plate or a Frisbee held down by a fishing weight. Make a slit in the middle of the plate and secure a 4-5 ft. tape measure with permanent bonding glue or a hot glue gun so that the zero point is at the slit. Glue the fishing weight to the bottom of the plate or Frisbee. Use waterproof paint to color one half of the plate's top surface black. This turbidity gauge is lowered into the water until it is no longer visible. (S) record this depth.

Temperature: (S) use a lab or aquarium thermometer to take and record the water temperature at several locations at the wetland sites. Let the thermometer stay in place for a minute or more at each location.

Rate of flow: (S) measure off 10 ft. by the side of the streambed. Set a tennis ball in the water at the beginning point, then release the ball and begin a stopwatch or note the time on a watch with a second hand that the ball reaches the end point. Record the time of the ball's travel and determine the rate of feet per second.

FIGURE 1. Water tests. *(S) stands for students and (T) stands for teacher.

Discover: The Water Cycle

Materials

1. Transparency of the water cycle and one paper copy of it for each student
2. One quart size plastic food storage bag with zipper closure for each student
3. 1/2 cup tiny aquarium gravel for each student
4. Black permanent markers for students to share in pairs or small groups
5. Masking tape
6. Water source

Make

1. Each student will tape the water cycle diagram to the desk and then tape a storage bag over it.
2. Students will trace the component steps onto their bags as the teacher traces and reviews the steps in the water cycle aloud at the overhead projector.
3. Students place the small gravel into the bags.
4. Students add about one cup of water to each bag and seal it tightly.

Do

1. Tape sealed food storage bags to the classroom windowpanes with the masking tape.
2. Have students identify, define, and locate the relevant key words that are on the bags, such as precipitation and condensation.

Explanation

The water cycle is a continuous process whereby the earth's water is recycled through the steps of accumulation, evaporation, condensation, precipitation, percolation, and transpiration. The cycle depends upon the sun's energy to transform water from liquid to vapor. This takes place when energy heats the water molecules enough to make them vibrate and move about vigorously. The water thus changes state and becomes a gas.

FIGURE 2. The water cycle.

Discover: Muddying the Water: Surface Water Pollution

Materials

1. Black 35mm film canister with cover for each simulated pollutant in step #3
2. A large open plastic (see-through) storage box, about half full of clean water
3. Various substances:

* brown leaves = trees in fall
* canned spinach = nitrates
* crumbs, paper bits = picnickers
* corn oil = boat oil
* baking soda = farm pesticide
* vinegar = acid rain runoff
* foil bits = litter from boaters
* baking powder = chemical dump
* mud = leaky sewer pipes
* loose soil = eroded soil
* soap = leaky drainage pipes/phosphates
* lemon juice = emissions from electric power plant

Make

1. Prepare and label the film canisters as entities identifying the various pollutants and sources.
2. Write a scenario or read the following: By the shores of Silver Lake live some residents who have problems with their drains and their sewage system. A nearby farmer uses deadly bug sprays to help his crops. An electric plant and a chemical factory are nearby. On pretty days, boaters use Silver Lake for waterskiing and fishing. Families like to picnic on the shore. After heavy rains, trees lose leaves and soil washes into the lake.

Do

1. Present the "lake" (plastic storage box) and have students suggest ways people and wildlife use lakes such as this. Pass out the canisters to the students who will portray the polluting characters in the story. As the tale unfolds, have students dump the contents of their canisters into the pristine "lake."
2. Have students describe the effects of such pollution on people and animals that live in or near the "lake."
3. Discuss what actions people might take to prevent some or nearly all of the pollution that took place in the story.

Explanation

The choices that people make in industry, social behavior, agricultural practice, household maintenance, and the like impact the environment.

Some of the examples given will lend themselves to a consideration of pH. You could sample the quality of the water by using the same chemical tests that you would use at a wetland site. Check for pH, nitrates, and phosphates before the first visitor or hazard enters the "lake," as well as at the story's end.

FIGURE 3. Muddying the water: Surface water pollution.

Discover: Cleaning the Waters: Filtration

Materials

1. One gallon water mixed with tea from opened one quart-sized tea bag
2. For each group of four, a wide-mouthed plastic container about one pint in volume and 2" or more in radius
3. For each group, a set of household materials such as kitchen sponge, cheesecloth, paper coffee filters, cotton balls, mesh vegetable bag, pebbles, or marbles

Make

1. Set up trays or areas around room for each group of four to invent their own best water filter for the mixed

tea water.

2. Provide scratch paper for sketching ideas and solutions to the problem.

Do

1. Describe a situation in which our reservoir has been contaminated with solid particles of foreign matter. For the water to be clean enough to use, each set of students has been hired to perfect a filtration device.

2. Set a time limit of about twenty minutes and ask each group to outline the sequence of cleaning materials they would use to share with the local water board after each is tested.

3. Pour the water evenly and in equal quantity over each filter. Discuss the results with students.

Explanation

Municipalities operate wastewater treatment plants as well as water treatment plants to assure citizens of a safe public water supply for household use. This simulation offers an example of such filtration as well as a model of the natural filtration provided by a wetland. Metaphors can be drawn by comparing the cleaning materials used in this activity to the living and nonliving parts of a wetland system. This activity makes a good connection to wetland metaphors (see Figure 6).

FIGURE 4. Cleaning the waters: Filtration.

Discover: Cattail Web of Life

Materials

1. Illustrations or magazine pictures of muskrats, red-winged blackbirds, mallard ducks, raccoons, catfish, nutria, marsh wrens, humans, beavers, cattails, and the sun

2. Sturdy card stock tags on which to glue pictures (label on the opposite side)

3. Pins or yarn strings to hold tags to students' clothing

4. A ball of thick yarn to be stretched from student to student

Make

1. Make or find pictures to illustrate the various factors in a life web involving the cattail (see materials).

2. One tag per student. Repeat species as needed, with two cattails for every other plant or animal.

Do

1. Provide illustrated tags to students and have them describe everything they know about the subject of the tag.

2. Have students form a circle around the pupil who is the sun. He or she holds the ball of yarn.

3. Solicit ideas of ways members of the circle need or provide for the needs of each other. If a suggestion is accepted, that student gets the ball next, trailing the yarn from the person who had it last.

3. Select an organism to remove because of some factor (e.g., ducks because raccoons ate their eggs). Ask students to tell the effects of this loss on the rest of the web.

Explanation

The cattail plants that grow in marshy wetlands are a source of food and shelter for wetlands wildlife and some humans as well. Humans, muskrats, beaver, and waterfowl use the cattail for food. Waterfowl and aquatic animals find shelters among cattails. Waterfowl, fish, and red-winged blackbirds nest in and below them. Sun and water are part of the web because life depends upon them. The simulation should indicate that the life forms benefit from one another.

FIGURE 5. Cattail web of life.

Discover: Metaphors in the Wetland

Materials

1. Collection of household objects such as sponge, sieve or strainer, egg beater or whisk, antacid tablet,

breakfast cereal, small pillow or doll bed, soap, coffee filter, and plastic model wetland animals
2. Cloth drawstring bag or pillowcase (a mystery bag) to hold the items listed above
3. Chart paper and markers or chalk/whiteboard and chalk or markers for recording student idea
4. Poster of a wetland area

Make
1. Fill cloth bag with house-hold materials that represent the plants, animals, and functions of wetlands.
2. Prepare chart paper or chalkboard to record students' comments. Create a web of interactions or interdependencies using students' ideas.

Do
1. Display a poster of an inhabited wetland area. Point out some of the plants and animals.
2. Introduce the mystery bag, saying it holds many items we use at home that serve us as much as parts of the wetlands serve living things there.
3. Record conclusions made by students as they think of metaphoric connections between the objects and the wetland.

Explanation
Aspects of a wetland compare to household items. A wetland collects runoff water as does a sponge. Wetlands provide food for animals just as cereal is a food for us. Wetlands mix nutrients and oxygen in the water just as an egg beater mixes fluids. Wetlands strain silt and pollutants just as a sieve separates seeds from fruit for us. Wetlands neutralize toxins like an antacid neutralizes acid in our stomachs. Wetlands clean the environment in these ways just as soap cleans us.
FIGURE 6. Metaphors in the wetland.

Discover: Precipitation and Condensation

Materials
1. Plastic soft drink bottle (2 liter) cut off at top
2. Aluminum foil to make snug new lid for bottle
3. 1 cup clean pebbles
4. Very hot water
5. Plastic food wrap
6. Ice cubes
7. Rubber band to encircle bottle

Make
1. Prepare snug concave lid from foil for open end of cut bottle.
2. Set the pebbles in the bottom of the bottle.
3. Have hot water and a quart of ice cubes ready.
4. Cut off a piece of plastic food wrap to go over foil lid and added ice cubes.

Do
1. Teacher pours very hot water over the pebbles to cover them.
2. Teacher sets foil lid firmly over top of bottle and fills with ice.
3. Cover ice and lid with plastic food wrap and secure with rubberband.

Why
When the hot water evaporates, it becomes vapor that moves up inside the bottle until it meets the foil and ice. The vapor condenses and becomes water again, then starts to fall as precipitation. The falling water will collect in the hot pebbles and reheat to start the cycle over again.
FIGURE 7. Precipitation and condensation.

Discover: Percolation

Materials

1. Several clean food cans, such as soup cans, with lids removed and the same number of same-sized holes punched into the bottom of each can
2. Water available to fill each empty can equally (approximately 2 cups per can)
3. Plastic rulers
4. Stopwatch or watch with second hand to time draining process
5. Clipboard, pencil, and paper to record results at different locations in school yard or at wetlands site

Make

1. Prepare clean, dry soup cans and punch holes to match. Fix one can to be placed in each spot on school grounds that has a different type of soil or ground cover.
2. Divide students into teams by the number of sites you will be testing, at least three per site. Name each team by soil or vegetation type, such as cement sidewalk, asphalt parking lot, grassy lawn, evergreen bed, rocky spot, gravel drive, and sandy flower bed.

Do

1. Lead a discussion about what students have observed when they have passed outside the school on rainy days. How does rain water move on the school grounds? Where does the rain collect and where does it run off?
2. Have one student from each team hold its can firmly over a spot at its site while another student pours the designated amount of water into the can. Other team members observe and time how long it takes for the can to empty. If the can does not empty, then students measure the depth of the water in the can.
3. Share reports and discuss possible explanations for differences.

Explanation

The hydrologic cycle carries water from the earth's surface into the atmosphere when transpired or evaporated. It precipitates down to the earth again as rain, snow, sleet, or hail. This water runs off into our streams and is absorbed into the soil. It gets into spaces between rocks or collects in the sea. Movement down under the earth's surface is called percolation.

The soils with spaces between rock, sand, or gravel particles take in water better than hard, solid surfaces do. Vegetation helps keep the soil loose, so the grass and plant beds should take the water well. Unyielding surfaces hold the water, and students can measure what stays back.

FIGURE 8. Percolation.

Discover: Transpiration and Evaporation

Materials

1. Transpiration:
   * One 10 oz clear glass tumbler per pair of students
   * Access to living grass in the out-of-doors
2. Evaporation:
   * One open plastic container per group of 4 students (all containers identical size and depth)
   * Equal amounts of tap water in each container
   * Plastic ruler for each group to measure depth
3. Writing materials to draw and record observations

Make

1. Locate likely areas on the school lawn for groups of students to gather and observe for about twenty minutes on a clear day.
2. Select several flat surfaces around the classroom with a range of exposures to the sun. These places should

be out of range for most likely accidental upsets. Make a series of graphs, one for each location, to record water depth over a series of ten school days.

Do

1. Students in small groups gather at their out-door spots, and the teacher turns the clear drinking glass over a patch of thick, healthy grass. Students wait and discuss any changes that occur. Share reports after glasses are picked up and class resumes.
2. Measuring carefully, students set out equal amounts of tap water in identical containers. Have groups of students measure the water in containers daily and record amounts on graphs for about two weeks. Compare measurements around the room, especially if locations have different exposures to the sun or to heating fixtures. Have students discuss results.

Explanation

Water becomes a gas if it evaporates because of heat of the sun. Water also evaporates if excess water is given off by green plants in a process known as transpiration. The first activity collects evidence of transpiration when the cool glass causes vapor emitted by the grass to condense and become visible. The second activity proves the loss of liquid water to evaporation by measuring quantities over time.

FIGURE 9. Transpiration and evaporation.

Discover: Cloud Formation

Materials

1. Large glass jar
2. Plastic bag of ice to fit over jar top
3. A sheet of stiff black paper as tall as the jar
4. Flashlight
5. Two dusty chalkboard erasers
6. Matches for teacher use
7. Hot water

Make

1. Tape the black paper to the back of the jar so you cannot see through it.
2. Warm enough water to fill the jar about 1/3 full of water.
3. Set the erasers near the flashlight.
4. Prepare the bag of ice and keep it cold.

Do

1. Dim the classroom lights. Have one student clap the erasers together while a second student shines the flashlight into the dust "cloud."
2. Fill the jar 1/3 full of hot water. Light one match and hold it over the jar opening. After a few seconds, drop the match into the jar and cover the top of the jar with the bag of ice. Observe the inside of the jar against the dark paper background. A "cloud" of water vapor will form around the smoke in the air.

Explanation

Water vapor that enters the atmosphere through transpiration by plants or evaporation of water that has accumulated on the earth's surface adheres to particles of matter in the air and forms clouds.

When the invisible water vapor in the air does this, the visible droplets or ice crystals that are formed become clouds.

The chalk dust particles are similar to dust or salt particles that help form clouds. The evaporating moisture from the jar condenses upon the particles of smoke.

FIGURE 10. Cloud formation.

Minimal start-up supplies and equipment:

Materials

* A class set of rubber boots
* A water quality or acid rain testing kit
* 5 aquatic dip nets
* 5 shallow, sturdy white plastic boxes
* Hand lenses
* Tweezers
* Probes for looking at macroinvertebrates (one set for each group of four students)
* 1 adult pair of waders (chest waders work best for deeper water)
* A kitchen timer
* Stopwatch
* Tennis ball
* 25' tape measure

FIGURE 11. Minimal start-up supplies and equipment.

Author Louise Monroe and student measure stream width from bank to bank.
Diana, Shawn, and Katryse look through aquatic sample for macroinvertebrate specimens to examine on plastic tray.
Teacher Louise Monroe helps students sift debris in net to locate macroinvertebrate specimens.
Diana, Kiin, and Katryse examine specimen. Diana uses key to identify class of macroinvertebrate for pollution tolerance.